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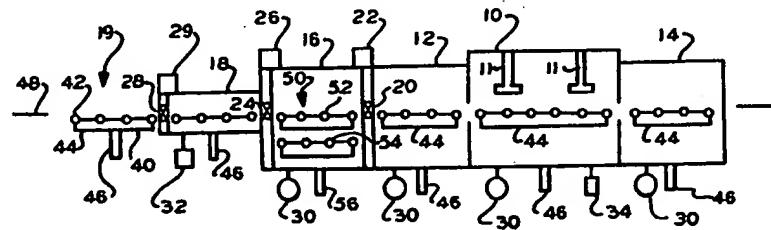
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(54) Vacuum processing apparatus and method

(57) A vacuum processing apparatus as illustrated in Fig. 1 includes a processing chamber 10 and a second chamber 16 which contains a workpiece transporting device 50 comprising two conveyors 52 and 54 on a common frame 60 and a means 70 for acting through a seal in the chamber wall for aligning the frame and each conveyor to transfer workpieces in opposite directions through the second chamber. The second chamber 16 may be an end lock with access to the outside or an intermediate lock or holding chamber between the processing chamber 10 and an end lock 18. A first gate valve 20 is operable to interconnect chambers 10 and 16, and a second gate valve 24 is operable to provide access to the second chamber 16. Preferably, the conveyors 52 and 54 comprise two parallel sets of horizontal rollers and an elevator for selectively aligning each set of rollers with a pass line 48 along which workpieces are transferred between the end lock 18 and the chamber 16 and between the chamber 16 and the processing chamber 10. The rollers of an aligned set may be driven by a magnetic coupling through the wall of chamber 1b.

The method involves the successive steps of:— a) processing a workpiece; b) transporting the processed workpiece from a first conveyor to a first chamber to a first level of a multi-level conveyor to a second chamber; c) aligning the second level of the multi-level with the first conveyor; d) transporting a first unprocessed workpiece from the second level onto the first conveyor, then sealing the first chamber from the second chamber; e) transporting a second unprocessed workpiece from a second conveyor outside the second chamber onto the second level; f) aligning the first level with the second conveyor; g) transporting the processed workpiece from the first level to the second conveyor; and h) sealing the second chamber.

FIG. 1



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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FIG. 1

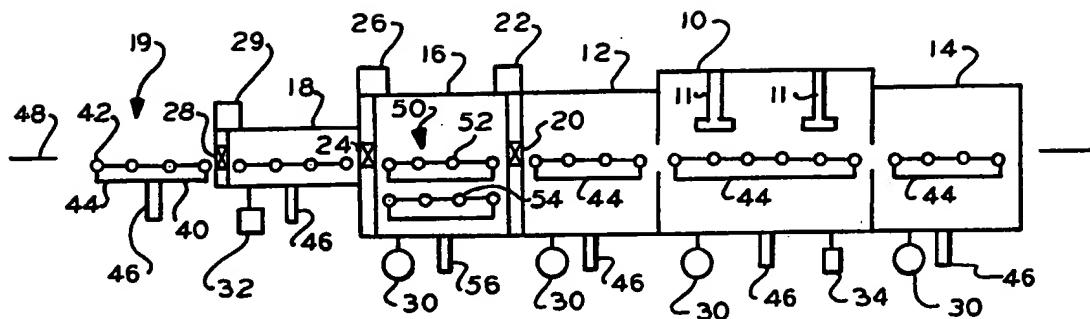


FIG. 2

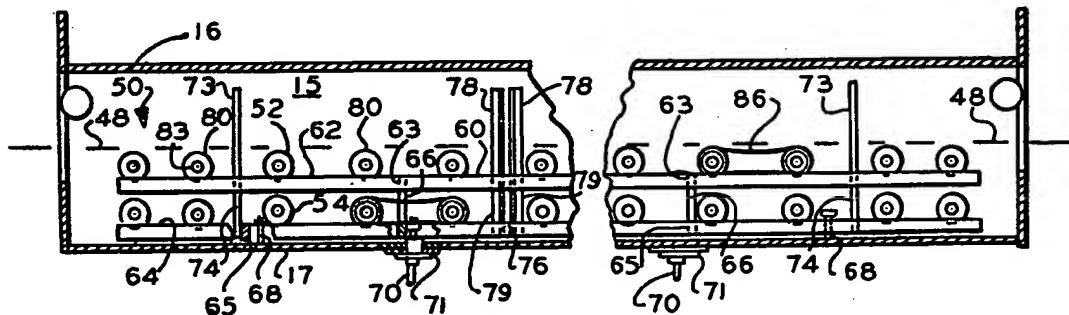


FIG. 3a

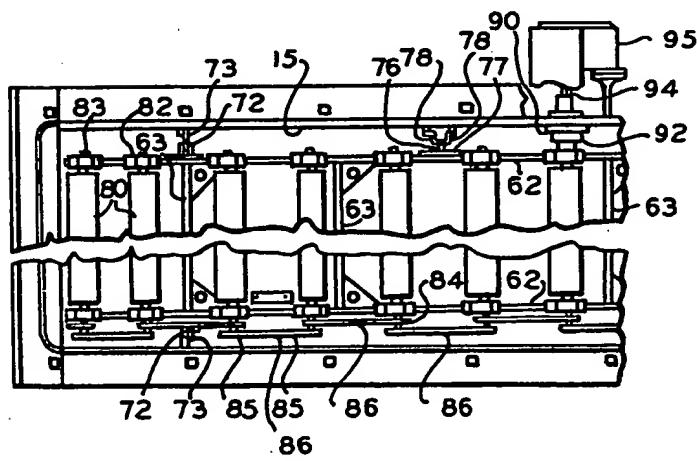
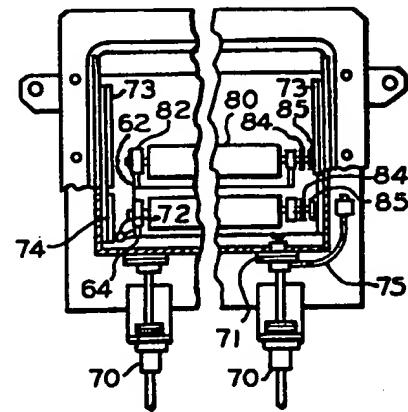
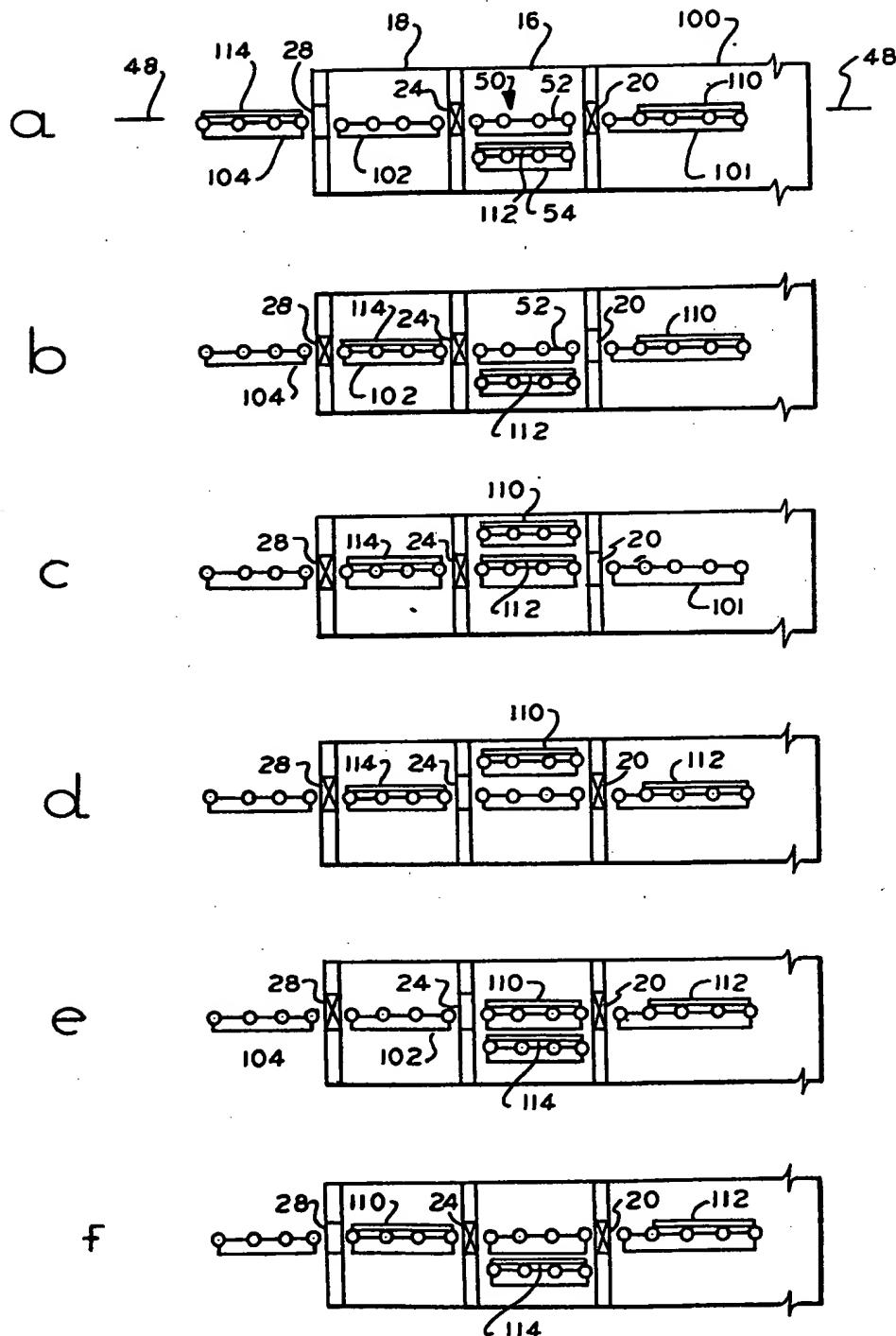


FIG. 3b



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FIG. 4



SPECIFICATION

Vacuum processing apparatus and method

This invention relates to transporting workpieces 5 into and out of a vacuum processing apparatus. The time required to transport workpieces into and out of vacuum apparatus and to pump down to a suitable pressure is frequently a limiting factor in the rate at which workpieces can be processed. This 10 is particularly true in high rate deposition processes where the coating time for an individual substrate is sometimes short compared to the time required to sufficiently evacuate the coating chamber. Coating apparatus has been developed where workpieces or 15 substrates are passed through separate vacuum locks on their way into and out of a coating or processing chamber. This increases the production rate because the volume of the lock can be minimized and processing can continue for 20 successive substrates without exposure of the processing chamber to atmospheric pressure. U.S. Patent 3,945,903 to Svendor et al discloses a vacuum coating system comprising entrance and exit locks and roller conveyors for transporting glass 25 sheets through the system.

In certain situations, the expense of a complete double-ended system with a vacuum lock at the both the entrance and exit of the coating chamber is not warranted. An alternative is to provide a single 30 lock and a reversible conveyor so that workpieces can enter and leave the processing chamber via the same lock. Such a system is called single-ended coater. U.S. patent 4,405,435 to Tateishi et al discloses a single-ended vacuum coating system 35 having multi-level workpiece cassettes and cassette elevators in both the lock and an intermediate chamber between the lock and the sputter coating chamber.

The invention provides a vacuum processing 40 apparatus as claimed in claim 1. The invention also provides a method as claimed in claim 8 of transporting workpieces into and out of a vacuum processing apparatus. The apparatus includes a processing chamber and a second chamber which 45 contains a workpiece transporting device comprising two conveyors on a common frame and a means for aligning the frame and each conveyor to transfer workpieces in opposite directions through the second chamber. The second chamber 50 may be an end lock with access to the outside or an intermediate lock or holding chamber between the processing chamber and an end lock. Preferably, the conveyors comprise two parallel sets of horizontal rollers and an elevator for selectively aligning each 55 set of rollers with a pass line along which workpieces are transferred between an end lock and a holding chamber and between a holding chamber and a processing chamber.

The invention will now be described by way of 60 example with reference to the accompanying drawings in which;

Figure 1 is a schematic representation of a side view of a vacuum coating apparatus incorporating the invention.

65 Figure 2 is a side view, partially in cross-section,

of a holding chamber incorporating a two-level workpiece transporting device according to the invention.

Figure 3a is a plan view of the holding chamber 70 and workpiece transporting device of Fig. 2.

Figure 3b is an end view, partially in cross section, of the holding chamber and workpieces transporting device of Figure 2.

Figures 4 (a) to (f) are schematic views of a 75 vacuum processing system comprising a processing chamber, a holding chamber and a vacuum lock which illustrate the method according to the invention.

Figure 1 illustrates a single-ended vacuum 80 processing apparatus comprising a processing chamber 10, a holding chamber 16, and a lock chamber 18. The vacuum process may be a coating process in which workpieces are transported from an entry buffer 12, passed a number of sputter coating sources 11 in the processing chamber and into an overrun buffer 14. The workpieces may be transported back and forth through the processing chamber 10 as required.

The processing area of the apparatus is separated 90 from the holding chamber 16 by a first internal gate valve 20 which may be opened or closed as desired by an actuator 22. The holding chamber 16 and the lock 18 are interconnected by a second internal gate valve 24 activated by an actuator 26. Access to the 95 lock 18 from a workpiece loading and unloading area 19 is by an external gate valve 28 operable by an actuator 29. The gate valves and actuator may be of conventional design suitable for transferring workpieces of the desired size and shape. One such gate valve is shown in U.S. Patent 4,065,097 to Timin.

Each of the chambers of the processing apparatus 100 is separately evacuable by conventional means. Lock 18 is evacuable by a blower or other mechanical pump 32. For sputtering or electron beam heated coating processes, holding chamber 16 and the processing chamber 10 are preferably evacuable by diffusion pumps 30. Processing chamber 10 may be provided with a source 34 of a desired sputtering gas.

Each chamber of the vacuum processing 110 apparatus is provided with a conveyor for supporting and transporting workpieces. For glass sheets and similar substrates, each conveyor preferably comprises a series of parallel, horizontal rollers 42 mounted on a frame 44 and driven by a reversible motor 46. Preferably the conveyors in the separate chambers are aligned to pass substrates into and out of the apparatus along a pass line 48.

120 In the preferred apparatus, the holding chamber 16 is provided with a plural-level transporting device 50 which moves vertically and which includes two horizontal conveyors 52 and 54 mounted one above the other on a common frame 60. As shown in Figures 2, 3a and 3b, the frame 60 comprises two parallel upper longitudinal members 62,

interconnected by a number of cross members 63, and two parallel lower longitudinal members 64, interconnected by a like number of cross members 125 65 aligned directly below the upper members. The

upper and lower members are connected by a number of uprights 66.

When frame 60 is in its lower position (shown in Figs. 2 and 3b) it rests on legs 68 which are 5 adjustable as necessary to ensure that the frame rests level on the bottom wall 17 of holding chamber 16. Additional legs and additional cross members between the side members may be provided as necessary depending upon the length of the 10 workpiece transporting device.

In Figures 2, 3a and 3b, the upper conveyor 52 of device 50 is aligned with the pass line 48. An elevator is provided in order to raise the frame 60 so that lower conveyor 54 is at the pass line. As shown, 15 the elevator comprises four ball screw jacks 70 which extend externally of the chamber 16 through vacuum seal assemblies 71 in the bottom wall 17. Each jack is provided with an oiler 75 to lubricate the seal assembly. Alternatively, the elevator may 20 comprise hydraulic or pneumatic cylinders.

Vertical motion of the transporting device 50 is guided by four lateral guide wheels 72, two of which are attached to the external face of each lower longitudinal member 64. The wheels roll along 25 upper 73 and lower 74 bar ways mounted on opposite side walls of chamber 16. The motion of the device 50 is also guided by a longitudinal guide wheel 76 mounted on an axle 77 perpendicular to one of the lower longitudinal members 64. Wheel 76 30 rolls between two upper ways 78 and two lower ways 79 mounted on one side wall 15 of chamber 16. The upper and lower ways for guide wheels 72 and 76 are aligned so that the device 50 is properly aligned in its raised and lowered positions, 35 respectively.

A number of rollers 80 are mounted for rotation in bearing blocks 82 aligned along side rails 62 (the blocks 82 are omitted from Fig. 2). One end of the axle 83 of each roller is fitted with two pulleys 84 40 and 85. As shown in Fig. 3a, corresponding pulleys of adjacent rollers are interconnected by belts 86 which ensure that the rollers turn simultaneously in the same direction.

The axle of one roller of whichever conveyor is at 45 the pass line is coupled by a magnetic means 90, 92 to shaft 94 which extends through a rotary seal in side wall 15. The rotating shaft is driven by a reversible motor 95 outside chamber 16.

Figure 4 illustrates the method of the invention.

50 Each part of the figure illustrates a processing chamber 100, a holding chamber 16 and a lock 18. The processing chamber may include entry and overrun buffers. Processing chamber 100 and holding chamber 16 are interconnected by a first 55 gate valve 20. Processing chamber 16 and lock 18 are interconnected by a second gate valve 24. Workpiece access to lock 18 is provided by a third gate valve 28. Processing chamber 100 contains a first conveyor 101 and the lock 18 contains a second 60 conveyor 102. As previously described, holding chamber 16 contains a workpiece transporting device 50 having two conveyors, upper level 52 and lower 54, and an elevator for aligning each conveyor with the pass line 48 through the vacuum 65 processing apparatus.

In Figure 4a, valves 20 and 24 are closed. One workpiece 110 is undergoing processing in chamber 100 and an unprocessed workpiece 112 is waiting on the lower level 54 of the transporting device 50 in

holding chamber 16. Since valves 20 and 24 are closed, chamber 16 may be evacuated by a diffusion pump and the pressure in the processing chamber 100 may be independently established, as desired. Valve 28 is open in order that a second unprocessed

70 75 workpiece 114 may be transported from conveyor 104 in the loading and unloading area onto conveyor 102 inside the lock as illustrated in Fig. 4b. Valve 28 may then be closed and lock 18 evacuated by a roughing pump.

80 Transporting device 50 is aligned so that the vacant conveyor 52 is at the pass line. When processing of workpiece 110 is completed, valve 20 is opened and workpiece 110 is transported onto the vacant upper conveyor 52. The transporting device

85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 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5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 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8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 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spirit of the invention which is defined by the following claims.

5 CLAIMS

1. A vacuum processing apparatus comprising:
first and second evacuable chambers;
a first gate valve interconnecting the first and
10 second chambers;
a second gate valve for providing access to the
second chamber;
a first workpiece conveyor in the first
chamber;
15 a second workpiece conveyor outside the first
and second chambers;
a workpiece transporting device in the second
chamber comprising
third and fourth workpiece conveyors
20 supported on a common frame;
and means for selectively aligning the frame
and each of the third and fourth conveyors to
transfer workpieces between the first and
second chambers when the first gate valve is
25 open and between the second chamber and the
second conveyor when the second gate valve is
open.
2. A vacuum processing apparatus as claimed
in claim 1, further comprising a third evacuable
30 chamber and wherein the second gate valve
interconnects the second and third chambers.
3. A vacuum processing apparatus as claimed
in claim 1 or claim 2, wherein the third and
fourth conveyors are parallel.
- 35 4. A vacuum processing apparatus as claimed
in claim 3, wherein each conveyor comprises a
number of parallel, substantially horizontal
rollers and a means for simultaneously turning
the rollers.
- 40 5. A vacuum processing apparatus as claimed
in claim 4, wherein the third and fourth
conveyors are supported one above the other,
and the conveyor aligning means comprises an

elevator for moving the frame in a vertical
45 direction.

6. A processing apparatus as claimed in claim
5, wherein the workpiece transporting device
further comprises wheels mounted on the frame
for guiding the movement of the frame.
- 50 7. A vacuum processing apparatus
substantially as herein described with reference
to the accompanying drawings.
8. A method for transporting workpieces into
and out of a vacuum processing apparatus
55 comprising:
processing a workpiece;
transporting the processed workpiece from a
first conveyor in a first chamber to a first level
of a multi-level conveyor in a second chamber;
60 aligning the second level of the multi-level
conveyor with the first conveyor;
transporting a first unprocessed workpiece
from the second level onto the first conveyor,
then sealing the first chamber from the second
chamber;
65 transporting a second unprocessed workpiece
from a second conveyor outside the second
chamber onto the second level;
aligning the first level with the second
70 conveyor;
transporting the processed workpiece from the
first level to the second conveyor; and
sealing the second chamber.
- 75 9. A method as claimed in claim 8, wherein
the second conveyor is inside a third sealable
chamber and further comprising:
transporting each processed workpiece out of
the apparatus from the second conveyor;
transporting each unprocessed workpiece from
80 outside the apparatus into the third chamber
onto the second conveyor; and
sealing and evacuating the third chamber.
- 85 10. A method for transporting workpieces into
and out of a vacuum processing apparatus,
substantially as herein described with reference
to the accompanying drawings.